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CERTIFICATE

Number 3320408

Applicant	Tangible_Design Team Japan
Submitted	Prototype of a Smart Radiation Detector “FRISK Radiation Meter” connected to an Apple iPod Touch. Software version 1.01, July 26, 2011
Calibration method	The use of the Smart Radiation Detector was according to the manufacturer. For the irradiations with ^{137}Cs and ^{60}Co gamma-rays a low scatter facility was used. The primary gamma-ray beam was collimated with a conical ring collimator according to ISO 4037-1. For the irradiations with beta rays of ^{90}Sr/^{90}Y a Buchler secondary standard beta-ray facility was used. The reference point of the Smart Radiation Detector, defined in the geometrical centre of the FRISK box, was positioned at the central axis of the beam. The site of the box with the text *FRISK* on it was facing the radiation source. During the period of calibration the environmental conditions were as follows: temperature 20 °C, atmospheric pressure between 101 kPa and 102 kPa and relative humidity 40 %.
Period of calibration	August 4, 2011 until August 9, 2011
Result	The results of the calibration are presented on page 2 until page 5. The reported uncertainty of measurement is based on the standard uncertainty of measurement multiplied by a coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The standard uncertainty of measurement has been determined in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM).
Traceability	The results of the calibration services of VSL are traceable to primary and/or (inter)nationally accepted measurement standards.

Delft, August 10, 2011
VSL B.V.

Drs. Ing. Cees van 't Wout
Manager Calibrations & Reference Materials

Frans J.M. Bader
First Metrologist & Supervisor Radiation Safety

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This certificate is consistent with Calibration and Measurement Capabilities (CMCs) that are included in Appendix C of the Mutual Recognition Arrangement (MRA) drawn up by the International Committee for Weights and Measures (CIPM). Under the MRA, all participating institutes recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details see http://kcdb.bipm.fr).

CIPM MRA

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Results

SDD is the distance between the reference point of the source and the reference point of the Smart Radiation Detector.

Beam is the diameter of the radiation beam at the reference point of the Smart Radiation Detector.

The response of the Smart Radiation Detector for gamma rays of ^{137}Cs and ^{60}Co is given by:

$$\text{Response} = H^*(10) \times M^{-1}$$

The response of the Smart Radiation Detector for beta rays of ^{90}Sr/^{90}Y is given by:

$$\text{Response} = D_{tissue}(0.07) \times M^{-1}$$

Where:
M is the indication of the Smart Radiation Detector obtained from the Apple iPod Touch and corrected for background. The stated uncertainty in the indication *M* is based on statistical fluctuations only.

$H^*(10)$ is the reference ambient dose equivalent rate according to ISO 4037-3.

$D_{tissue}(0.07)$ is the reference absorbed dose to soft tissue at a depth of 0.07 mm.
The value of the quantity absorbed dose to soft tissue at a depth of 0.07 mm corresponds to the quantity $H'(0.07)$ when the unit Gy is replaced by the unit Sv. Soft tissue is taken as 10.1 % H; 11.1 % C; 2.6 % N and 76.2 % O; with a density of 1 g/cm^3.

Table 1: First experiment

Threshold: 13 % (default)
Time Range: 30 s (default)
Background: between 0 cpm and 2 cpm

Nuclide	*SDD* cm	Beam cm	*H**(10) Sv/h	*M* cpm	Response (μSv/h) / cpm
^{137}Cs	200	Ø 30	0.58 μ ± 7 %	6 ± 3	0.097
^{137}Cs	200	Ø 30	6.76 μ ± 5 %	86 ± 7	0.079
^{137}Cs	200	Ø 30	65.2 μ ± 5 %	898 ± 25	0.073
^{137}Cs	200	Ø 30	739 μ ± 5 %	10349 ± 50	0.071
^{137}Cs	200	Ø 30	5.79 m ± 5 %	71999 ± 1000	0.080

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Table 2: Second experiment

Threshold: 13 % (default)
Time Range: 30 s (default)
Background: between 0 cpm and 2 cpm

Nuclide	*SDD* cm	Beam c	*H**(10) Sv/h	*M* cpm	Response (µSv/h) / cpm
^{137}Cs	200	Ø 30	0.58 µ ± 7 %	8 ± 6	0.073
^{137}Cs	200	Ø 30	6.76 µ ± 5 %	95 ± 6	0.071
^{137}Cs	200	Ø 30	65.2 µ ± 5 %	934 ± 35	0.070
^{137}Cs	200	Ø 30	739 µ ± 5 %	10299 ± 200	0.072
^{137}Cs	200	Ø 30	5.79 m ± 5 %	72499 ± 500	0.080
^{60}Co	200	Ø 30	35.3 µ ± 5 %	463 ± 32	0.076
^{60}Co	200	Ø 30	317 µ ± 5 %	3999 ± 100	0.079

Table 3: Third experiment

Threshold: 13 % (default)
Time Range: 200 s
Background: between 0 cpm and 2 cpm

Nuclide	*SDD* cm	Beam Cm	*H**(10) Sv/h	*M* cpm	Response (µSv/h) / cpm
^{137}Cs	200	Ø 30	0.58 µ ± 7 %	background	---
^{137}Cs	200	Ø 30	6.76 µ ± 5 %	92 ± 1	0.073
^{137}Cs	200	Ø 30	65.2 µ ± 5 %	895 ± 5	0.073
^{137}Cs	200	Ø 30	739 µ ± 5 %	10200 ± 300	0.072
^{137}Cs	200	Ø 30	5.79 m ± 5 %	70650 ± 150	0.082
^{60}Co	200	Ø 30	35.3 µ ± 5 %	414 ± 2	0.085
^{60}Co	200	Ø 30	317 µ ± 5 %	4050 ± 50	0.078

Without the copper shield
Background: 9 cpm ± 2 cpm

Nuclide	*SDD* cm	Beam cm	$D_{tissue}(0.07)$ mGy/h	*M* cpm	Response (µGy/h) / cpm
^{90}Sr/^{90}Y	30	Ø 10	4.46 ± 6 %	30450 ± 550	0.146
^{90}Sr/^{90}Y	30	Ø 10	4.46 ± 6 %	30000 ± 1000	0.149

Table 4: Linearity and reproducibility

Data adopted from table 1, 2 and 3.

Nuclide	$H^*(10)$ Sv/h	M cpm First experiment	M cpm Second experiment	M cpm Third experiment
^{137}Cs	0.58 μ ± 7 %	6 ± 3	8 ± 6	background
^{137}Cs	6.76 μ ± 5 %	86 ± 7	95 ± 6	92 ± 1
^{137}Cs	65.2 μ ± 5 %	898 ± 25	934 ± 35	895 ± 5
^{137}Cs	739 μ ± 5 %	10349 ± 50	10299 ± 200	10200 ± 300
^{137}Cs	5.79 m ± 5 %	71999 ± 1000	72499 ± 500	70650 ± 150
^{60}Co	35.3 μ ± 5 %	not measured	463 ± 32	414 ± 2
^{60}Co	317 μ ± 5 %	not measured	3999 ± 100	4050 ± 50

Nuclide	$D_{tissue}(0.07)$ mGy/h	M cpm First experiment	M cpm Second experiment	M cpm Third experiment
$^{90}Sr/^{90}Y$	4.46 ± 6 %	not measured	30450 ± 550	30000 ± 1000

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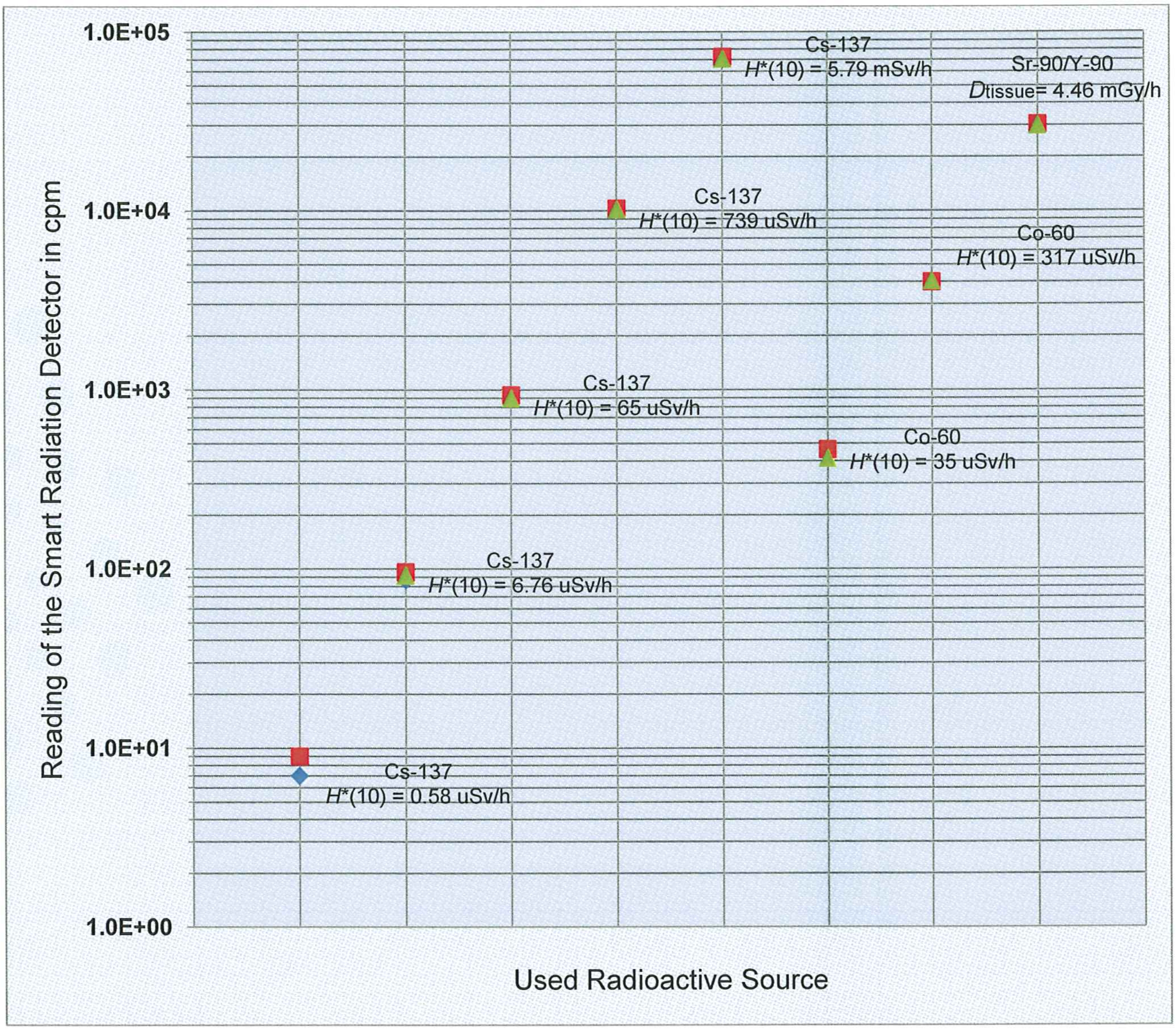

Figure 1: *Results for linearity and reproducibility of the Smart Radiation Detector. Data adopted from table 4.*

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Notes

According to the recommendations of ISO and ICRU it's necessary that the Smart Radiation Detector is scaled in the quantity Ambient Dose Equivalent Rate, symbol $H^*(10)$ with the unit Sv/h, when used as a radiation survey monitor for gamma- and x-rays.

References

International Standard ISO 4037-1, 1997. X and gamma reference radiation for calibrating dosemeters and doserate meters and determining their response as a function of photon energy.
Part 1: Characteristics of the radiations and their methods of production.

International Standard ISO 4037-2,1997. X and gamma reference radiation for calibrating dosemeters and doserate meters and determining their response as a function of photon energy.
Part 2: Dosimetry for radiation protection over the energy ranges 8 keV to 1.3 MeV and 4 MeV to 9 MeV.

International Standard ISO 4037-3, 1999. X and gamma reference radiation for calibrating dosemeters and doserate meters and determining their response as a function of photon energy.
Part 3: Calibration of area and personal dosemeters.

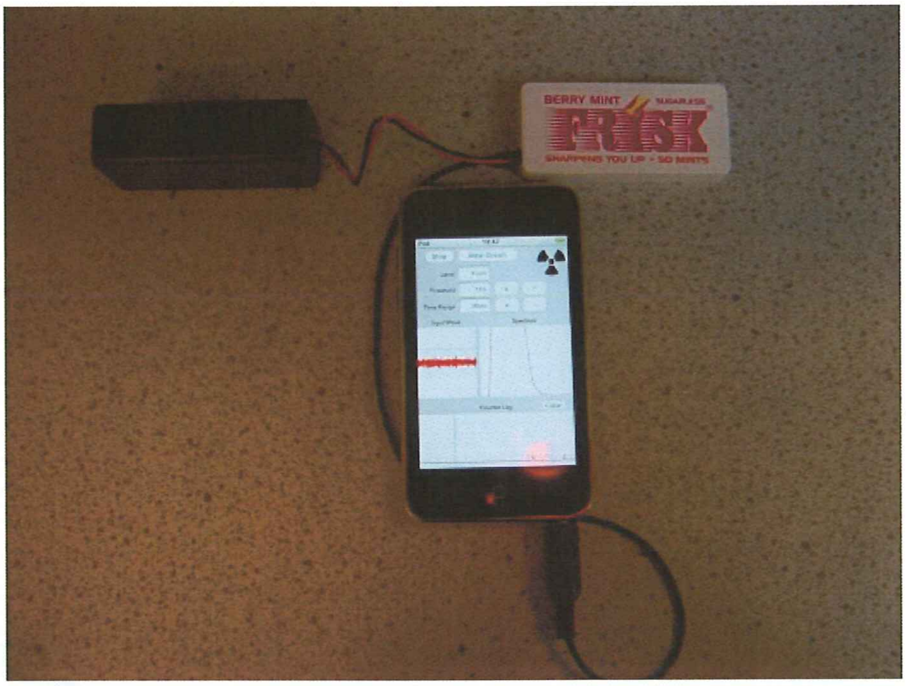

Figure 2: *Smart Radiation Detector "FRISK Box" with the 9 V power supply (black box) connected to an Apple iPod Touch.*

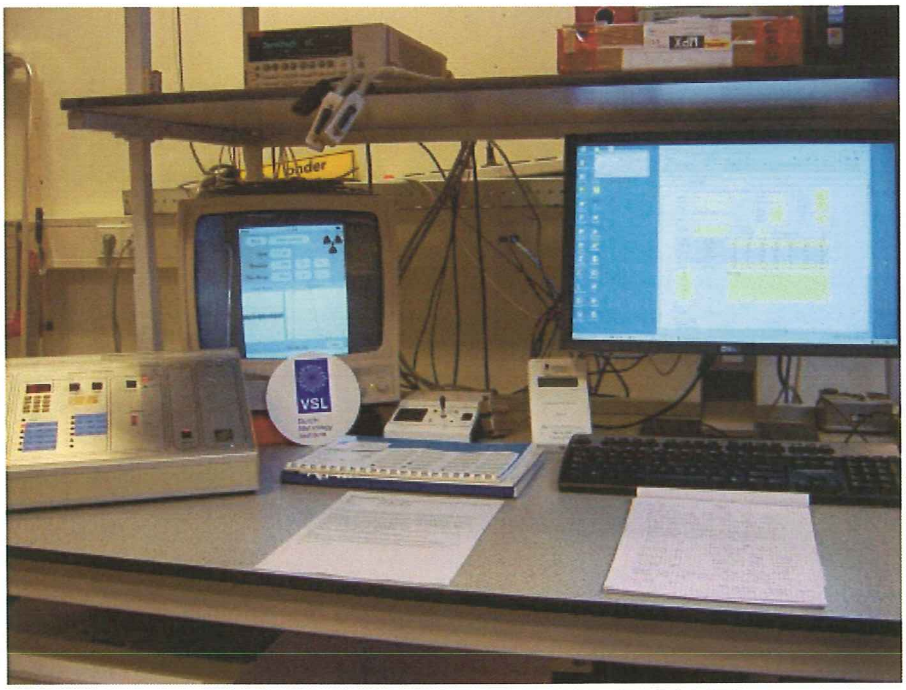

Figure 3: *View of the control desk.*

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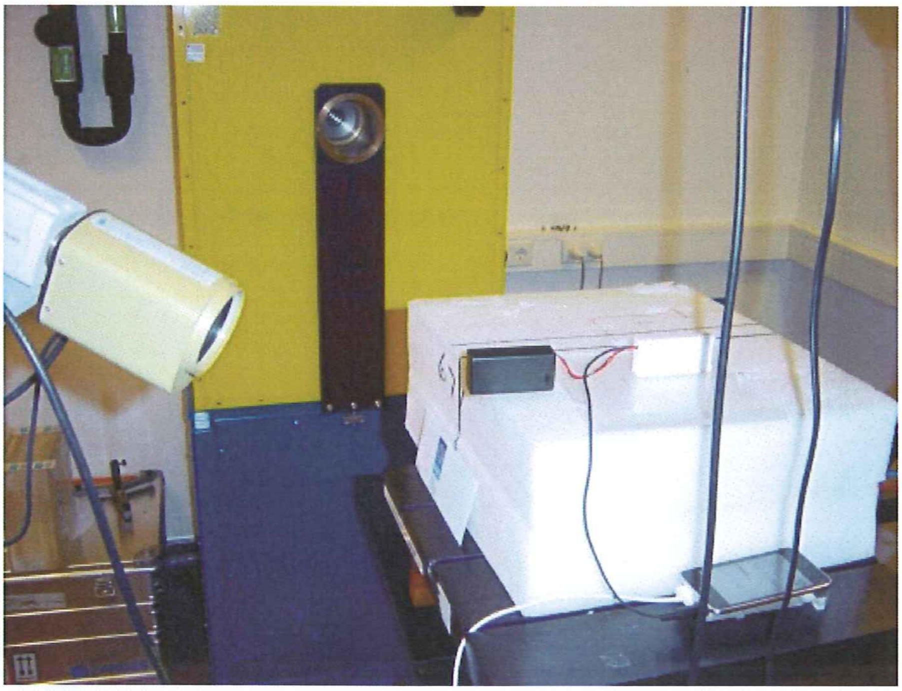

Figure 4: *Set-up for irradiation with gamma-rays of* ^{137}*Cs and* ^{60}*Co.*

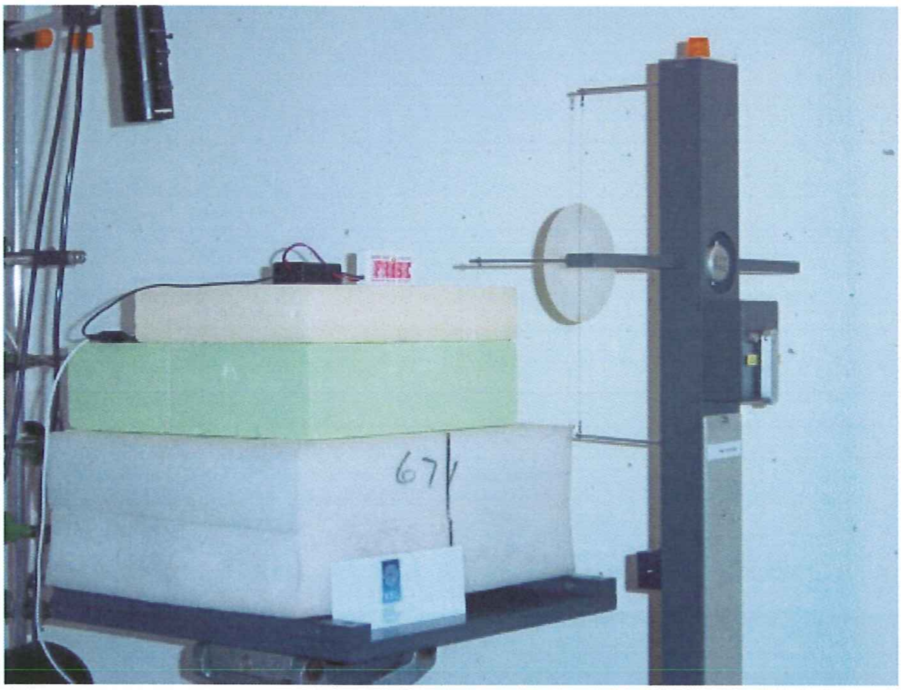

Figure 5: *Set-up for the irradiation with beta-rays of* ^{90}*Sr/*^{90}*Y.*